

2.0 INTRODUCTION

2.1 Background

Lifelines (e.g., systems and facilities that deliver energy and fuel and systems and facilities that provide key services such as water and sewage, transportation, and communications are defined as lifelines) are presently being sited in "utility or transportation corridors" to reduce their right-of-way environmental, aesthetic, and cost impacts on the communities that rely upon them. The individual lifelines are usually designed, constructed, and modified throughout their service life. This results in different standards and siting criteria being applied to segments of the same lifeline, and also to different standards or siting criteria being applied to the separate lifelines systems within a single corridor. Presently, the siting review usually does not consider the impact of proximity or collocation of the lifelines on their individual risk or vulnerability to natural or manmade hazards or disasters. This is either because the other lifelines have not yet been installed or because such a consideration has not been identified as being an important factor for such an evaluation.

There have been cases when some lifeline collocations have increased the levels of damage experienced during an accident or an earthquake. For example, water line ruptures during earthquakes have led to washouts which have caused foundation damage to nearby facilities. In southern California a railroad accident (transportation lifeline) led to the subsequent failure of a collocated fuel pipeline, and the resulting fire caused considerable property damage and loss of life. Loss of electric power has restricted, and sometimes failed, the ability to provide water and sewer services or emergency fire fighting capabilities.

In response to these types of situations, the Federal Emergency Management Agency (FEMA) is examining the use of such corridors, and FEMA initiated this study to examine the impact of siting multiple lifeline systems in confined and at-risk areas.

The overall FEMA project goals are to develop managerial tools that can be used to increase the understanding of the lifeline systems' vulnerabilities and to help identify potential mitigation approaches that could be used to reduce those vulnerabilities. Another program goal is to identify methods to enhance the transfer of the resulting information to lifeline system providers, designers, builders, managers, operators, users, and regulators.

This report is the second of a series of three reports. The first report^{(1)*} presented an inventory of the major lifeline systems located at Cajon Pass, California, and it summarized the earthquake and geologic analysis tools available to identify and define the

* The numbers in superscript are references found at the end of each chapter.

level of seismic risk to those lifelines. This report presents the analytic methods developed to define the collocation impacts and the resulting analyses of the seismic and geologic environmental loads on the collocated lifelines in the Cajon Pass. The assumed earthquake event is similar to the 8.3 magnitude, San Andreas fault, Ft. Tejon earthquake of 1857. In this report a new analysis method is developed and applied to identify the increase in the vulnerability of the individual lifeline systems due to their proximity to other lifelines in the Cajon Pass. A third report⁽²⁾ presents an executive summary of the study. The Cajon Pass Lifeline Inventory report and this present report taken together provide a specific example of how the new analysis method can be applied to a real lifeline corridor situation.

2.2 Study Approach

The approach used to develop the information for this report was as follows. The Cajon Lifeline Inventory report⁽¹⁾, additional information provided during direct meetings with the lifeline owners, site reconnaissance surveys to validate the information and to examine specific site conditions of interest to the study, and existing literature that describes lessons learned from actual earthquake events were compiled and thoroughly studied. The principal investigators then hypothesized an analysis method that could be applied to the Cajon Pass lifelines to estimate the impacts of proximity on their earthquake-induced performance and repairs.

This analysis method emphasizes building upon existing data bases and analytic methods. In applications, it is recommended that the analyses, studies, and information available from the lifeline owners be used whenever possible. In the event that sufficient data on the lifeline response to earthquakes and the expected time to restore the lifeline back to its required service level are not available from the lifeline owners, the analytic methods, with some important modifications, of "Earthquake Damage Evaluation Data for California", ATC-13⁽³⁾ are recommended as an appropriate alternative analysis method. In this project the "most probable restoration time" was defined as the analysis parameter that best could be used to define the impact of lifeline proximity on the individual lifeline's earthquake vulnerability.

The resulting method was then applied to the Cajon Pass lifelines. The U.S. Geologic Survey's digitized topographic map of the Cajon Pass and the contiguous quadrangles were utilized. The commercial, computer aided, design program AutoCAD was used as it is readily available to the public, thus the methodology is not limited to being dependent upon a specialized or proprietary computer program. With this tool, overlays of the lifeline routes with seismic and geologic information presented in the inventory report⁽¹⁾ were used to identify the conditions and locations where the individual lifelines were most vulnerable to the hypothesized earthquake. The